

Suppression of X-rays during an optical outburst of the helium dwarf nova KL Dra

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ABSTRACT

KL Dra is a helium accreting AM CVn binary system with an orbital period close to 25 mins. Approximately every 60 days there is a 4 mag optical outburst lasting ~ 10 days. We present the most sensitive X-ray observations made of an AM CVn system during an outburst cycle. A series of eight observations were made using *XMM-Newton* which started shortly after the onset of an optical outburst. We find that X-rays are suppressed during the optical outburst. There is some evidence for a spectral evolution of the X-ray spectrum during the course of the outburst. A periodic modulation is seen in the UV data at three epochs – this is a signature of the binary orbital or the superhump period. The temperature of the X-ray emitting plasma is cooler compared to dwarf novae, which may suggest a wind is the origin of a significant fraction of the X-ray flux.

Key words: Stars: individual: – KL Dra – Stars: binaries – Stars: cataclysmic variables – Stars: dwarf novae – X-rays: stars

1 INTRODUCTION

Amongst the thousands of known cataclysmic variables (CVs) are a group of more than two dozen systems, known as ‘ultra-compact’ or ‘AM CVn’ binaries, which have orbital periods between ~ 5 –70 minutes and spectra devoid of hydrogen (see Solheim 2010 for a recent review). These systems are composed of white dwarfs accreting from the hydrogen depleted cores of their companions, an idea supported by evidence for CNO processing (Marsh et al 1991). Like many CVs, a number of AM CVn binaries show outbursts in the optical and near UV when they brighten typically 2–5 magnitudes (Ramsay et al 2012). These outbursts are assumed to be similar to those seen in the hydrogen accreting dwarf novae, which show regular outbursts lasting days to weeks with recurrence times of weeks to months.

In 2009 we started a survey of sixteen AM CVn systems to determine how often they go into outburst and whether the outbursting systems had orbital periods in the range 20–40 mins, as predicted by Tsugawa & Osaki (1997) (see also Cannizzo 1984). Observations of each target were made approximately once per week using the Liverpool Telescope. Our study found that roughly 1/3 of AM CVn systems showed at least one outburst and that the outburst-

ing systems have an orbital period in the range 24–44 mins (Ramsay et al 2012) which was remarkably consistent with predictions.

KL Dra is an AM CVn binary which has an orbital period close to 25 mins (Wood et al 2002). Our survey found that KL Dra undergoes an outburst every two months (Ramsay et al 2010, 2012) making it very similar to hydrogen accreting dwarf novae. We obtained near-UV and X-ray observations of KL Dra using the *Swift* satellite and found that although it was a strong UV source during optical outburst, we found no strong evidence for a variation in the X-ray flux over the outburst cycle (Ramsay et al 2010).

With the greater sensitivity of the X-ray telescopes on board the *XMM-Newton* satellite compared to *Swift*, we have obtained a series of eight ‘Target of Opportunity’ (ToO) observations of KL Dra during an optical outburst to determine if the X-ray flux was suppressed during the outburst as has been observed in a number of dwarf novae outbursts (eg Wheatley et al 1996).

2 OBSERVATIONS AND DATA REDUCTION

2.1 Overview

As KL Dra undergoes outbursts with a duration lasting approximately 10 days every 60 days, we are able to predict the time of future outbursts. Although the outburst recurrence time varies from 45 to 65 days (see Ramsay et al 2012 for details) our accuracy was expected to be good to within a handful of days. Using observations obtained using the robotic 2.0m Liverpool Telescope (LT) on La Palma, KL Dra was observed to go into outburst at some point between 14–15 July 2011. Allowing for the fact that the next outburst maybe earlier than predicted, we scheduled our set of eight *XMM-Newton* observations to start on 19 Sept 2011. (This was deemed preferable to obtaining a dedicated monitoring campaign coupled with a ToO request with a very short reaction time). In the event, the outburst of KL Dra began slightly earlier than anticipated as it was observed in outburst on 14 Sept 2011.

2.2 Liverpool Telescope observations

We obtained a series of images using the LT and the RAT-CAM imager and a g band filter (Steele et al 2004). Data were reduced in the same manner as that described in Ramsay et al (2012). The first image was obtained on 14 Sept 2011 (MJD=55818) when KL Dra was seen at $g=16.0$ (Figure 1). Further observations showed it was still in a bright optical state until MJD=55830 when there was a rapid decline in brightness, reaching $g=19$ by MJD~55830. A short duration outburst was seen at MJD=55843 (similar to that seen in one epoch in the historic data in the top panel of Figure 1) after which it returned to a faint optical state. We show all the previous optical data of KL Dra in the top panel of Figure 1 which has been phased so that different outbursts start at the same time (taken from Ramsay et al 2012). These optical data show a distinct ‘dip’ in the light curve around 5 days after the start of the outburst. Although this dip is also seen in the UV (Ramsay et al 2012), its origin is not clear. These ‘historic’ data have then been shifted (by eye) so that they align with our LT observations of the Sept 2011 outburst. This suggests that the start of the Sept 2011 outburst occurred only two days before the first LT observations.

2.3 *XMM-Newton* observations

The *XMM-Newton* satellite has three X-ray telescopes and a optical/UV telescope (the Optical Monitor, OM) on-board. We show the observation log in Table 1 for the EPIC MOS X-ray detector. The EPIC detectors have an energy range 0.2–12keV; modest spectral resolution ($E/dE \sim 50$ at 6.5keV) and relatively high time resolution (73 ms for the EPIC pn detector and 2.36 sec for the EPIC MOS detector). Data from the high resolution grating X-ray spectrometers (the RGS) were not analysed since the signal-to-noise of our source was very low. The OM was configured in fast mode and we used the UVW1 filter (2400–3400 Å).

The data were reduced using *SAS* v11.0. For each EPIC detector, only X-ray events which were graded as *PATTERN*=0-4 and *FLAG*=0 were used. Events were extracted

ObsId	Start Time	Duration (sec)
0673800201	2011-09-19 04:20:08	12421
0673800301	2011-09-21 06:55:13	10623
0673800401	2011-09-22 21:48:44	16622
0673800501	2011-09-24 21:41:07	19663
0673800601	2011-09-26 21:33:47	23620
0673800701	2011-09-28 22:22:12	19260
0673800801	2011-09-30 22:08:40	11349
0673800901	2011-10-03 06:01:34	11018

Table 1. The summary for our *XMM-Newton* observations of KL Dra taken in Sept 2011 where we show the observation identification number (ObsId), and the start time and duration for the EPIC MOS1 detector (these are almost identical to the EPIC MOS2 detector, while the duration of the EPIC pn observations were typically shorter by 1.6 ksec).

from a circular aperture with radius $26''$ centered on the source, with background events being extracted from two source free regions each with an aperture of radius $50''$. The background counts were scaled by the ratio of the source to background region areas and then subtracted from the counts in the source aperture. Given the low count rate from our source, pile-up was not an issue. The OM data were reduced using *omfchain* and other *SAS* tasks.

We show the X-ray count rate for the EPIC pn and EPIC MOS (1 and 2 combined) detectors in Figure 1. It is clear that when KL Dra is in optical outburst, the X-rays are detected at a low (but significant) level: the mean of the first four epochs of data is 0.0150 ± 0.0008 ct/s in the EPIC pn detector. When the optical flux rapidly decreases at MJD~55830, the X-ray count rate remains low. In the next observation, the X-ray flux has significantly increased: the mean of the last 3 epochs of data is 0.0430 ± 0.0016 ct/s. There is therefore an increase in the X-ray flux of 2.9 in the optical low state compared to the optical high state.

We also show the X-ray hardness derived using the EPIC pn and MOS detectors (where we have combined the data from the MOS1 and MOS2 detectors) in Figure 1. We show two measures of X-ray hardness: $HR1 = (Band2 - Band1) / (Band2 + Band1)$ and $HR2 = (Band3 - Band2) / (Band3 + Band2)$, where $Band1 = 0.2 - 0.5$ keV, $Band2 = 0.5 - 1.0$ keV, $Band3 = 1 - 2$ keV. Apart from the $HR1$ hardness measure derived from the EPIC pn detector, there is no evidence for a significant variation in the hardness ratio over the series of observations. The $HR1$ ratio derived from the EPIC pn detector shows that the X-ray spectrum gets harder over the course of the first five observations, after which it gets softer. The fact that $HR2$ hardness ratio does not change significantly implies the variation is likely caused by a decrease in flux of the softest X-rays. We attribute the fact that a spectral change is not observed in the EPIC MOS detectors to the very low count rate at softest energies (the effective area at the softest energies is higher in the EPIC pn detector camera compared to the EPIC MOS detectors). We compare these results with hydrogen accreting dwarf novae in §5.

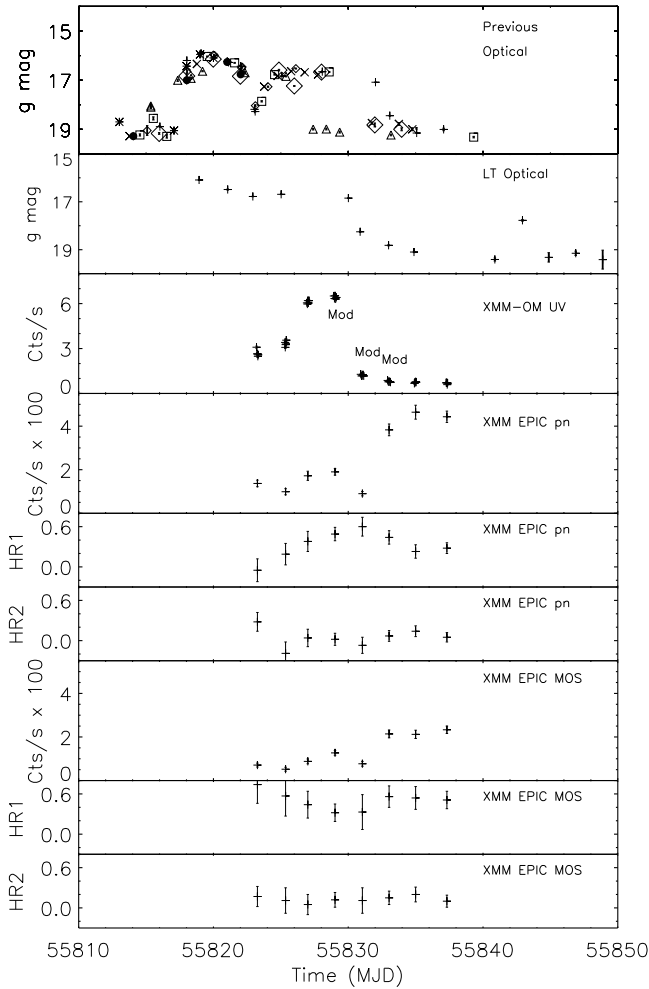


Figure 1. The light curve of KL Dra in Sept 2011 as observed in different energy bands. From the top: historic observations of KL Dra made using the LT and plotted so that different outbursts (which are shown as different symbols) are ‘in-phase’ (taken from Fig 4 of Ramsay et al 2012); the optical magnitude derived from observations made using the LT in Sept 2011; the UV count rate in the UVW1 filter (‘Mod’ implies that a modulation on a period close to ~ 25 mins was detected in the UV data); the X-ray flux derived from the EPIC pn detector and the softness ratio HR1 and HR2 in the EPIC pn detector, followed by the same parameters but for the combined MOS detectors.

3 THE UV AND X-RAY LIGHT CURVES

Wood et al (2002) found evidence for a photometric modulation in optical data of KL Dra taken in outburst and quiescence. In outburst they detected a period of 25.5 min (which they took to be the super-hump period) and in quiescence a period of 25.0 min (which they took to be the orbital period). Super-humps are caused by the precession of features in the accretion disc such as the hot bright spot in the disc where the accretion flow from the secondary star impact the disc. We therefore made a search for variability in the near UV and X-ray data of KL Dra.

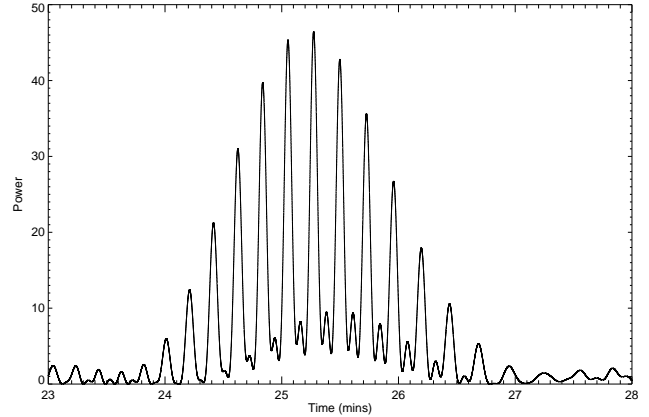


Figure 2. The power spectra of the light curve derived from epochs 4–6 where we have de-trended and normalised each individual light curve.

3.1 The UV data

Initially we binned the data in 10 sec bins and obtained Power Spectra for each epoch of data. We find evidence for significant power in the 4th (just before the rapid decline in UV flux), 5th and 6th (when the system is in quiescence) epochs of data (cf Table 1). We mark the epochs in which significant power was detected as ‘Mod’ in the panel third from the top in Figure 1. The period of the most significant peak in each power spectra was at 25.4 ± 1.2 , 25.2 ± 1.3 and 25.3 ± 1.0 mins. These periods are very close to the super-hump period of 25.5 min and orbital period of 25.0 min reported by Wood et al (2002).

For those epochs in which significant power was detected, we de-trended the data and normalised them so that the mean count rate was zero. We then obtained a power spectrum of this combined light curve (shown in Figure 2). Because of the sampling frequency there is strong aliasing. However, the period of the maximum peak is 25.27 ± 0.04 mins (derived from the Full Width Half Maximum of the peak), and nearest alias peaks at 25.05 ± 0.04 and 25.50 ± 0.04 mins. Using consecutive days of high speed photometry Wood et al (2002) obtained a best fit period of 25.5142 ± 0.0001 mins. We are unable to unambiguously determine whether the modulation is due to the orbital modulation or a super-hump.

We show the folded and binned light curves in Figure 3, (where we include the epochs immediately before and after the detection of a significant modulation), while we give their amplitude in Table 2. We find a peak amplitude of 22 percent in our near UV observations, while Wood et al (2002) find a full amplitude of less than 10 percent in optical data of KL Dra taken in both outburst and quiescence. Prominent oscillations (~ 7 percent amplitude) were also seen in near-UV observations of the AM CVn binary HP Lib (Ramsay et al 2005). Wood et al (2011) and Barclay et al (2012) (for instance) show how the shape of the folded light curve can give insight to the accretion behaviour. For instance, light curves which showed a main and a secondary peak (for which there is weak evidence in the second from bottom panel of Figure 3), were taken as evidence that the optical emission originated from the hot-spot (where the ac-

ObsId	Mean Cts/s	8 sec Amp	25 min Amp	10 sec rms	30 sec rms	60 sec rms
0673800201	2.31	< 17%	< 12%	0.61	0.37	0.29
0673800301	2.87	< 24%	< 15%	0.63	0.39	0.30
0673800401	5.40	< 11%	< 17%	0.89	2.79	0.34
0673800501	5.79	< 17%	8%	0.92	0.56	0.39
0673800601	0.85	< 6%	19%	0.49	0.38	0.35
0673800701	0.64	< 7%	22%	0.32	0.19	0.13
0673800801	0.58	< 8%	< 9%	0.31	0.19	0.14
0673800901	0.54	< 9%	< 5%	0.30	0.17	0.12

Table 2. We show the mean count rate of the UVW1 data as a function of epoch; the measured (or upper limit) amplitude of a sinusoidal variation on a period of 8 sec and 25 min; and the rms variation for 10 sec, 30 sec and 60 sec binning.

cretion stream impacts the disc) and the disc itself. Superhumps have generally been detected in super-outbursts of hydrogen accreting CVs, but *Kepler* observations of CVs (Still et al 2010, Barclay et al 2012) have shown superhumps in super-outburst, normal outbursts and in quiescence, suggesting they may be more common than previously thought.

For those epochs which showed no evidence for significant variability on a period close to 25 mins, we were able to place an upper limit for their presence by injecting a sinusoid with a period of 25 mins and a range of amplitude. We then obtained a power spectrum of these light curves and tested for the presence of a significant peak in the power spectrum near 25 mins (a peak in the power spectrum was regarded as significant if the False Alarm Probability for power at 25 mins, as determined using the Lomb Scargle test, corresponded to 3σ). We note these limits in Table 2.

Mauche (1996) presented EUVE data of SS Cyg in outburst in which he detected dwarf nova oscillations on a period between 7.5–9.3 sec and amplitudes ~ 15 percent. We therefore placed limits on the presence of very short period oscillations in our UV data by injecting a sinusoid with a range of periods into the light curves with a range of amplitude. As an example, we show in Table 2 the upper limits to the amplitude of a signal with a period of 8 sec. The lowest limit to the amplitude was 6 percent made at the epoch when the source had declined in UV brightness. If oscillations like those seen in SS Cyg were present in our near UV data of KL Dra we would have detected them in our data during optical quiescence. On the other hand our observations would not have detected the very low amplitude (< 1.2 percent) oscillations seen in optical photometry of AM CVn (Provencal et al 1995).

We also show the mean count rate and rms variation normalised to the mean count rate for different epochs and bin sizes in Table 2. In the light curves binned on 10 sec (and also 60 sec), we find that the light curves with the highest rms are in quiescence. The 30 sec binned light curves show a marked variation, with the optical outburst state showing both high and low levels of rms.

3.2 The X-ray data

We extracted events from a spatial region centered on KL Dra and obtained a Discrete Fourier Transform for each ob-

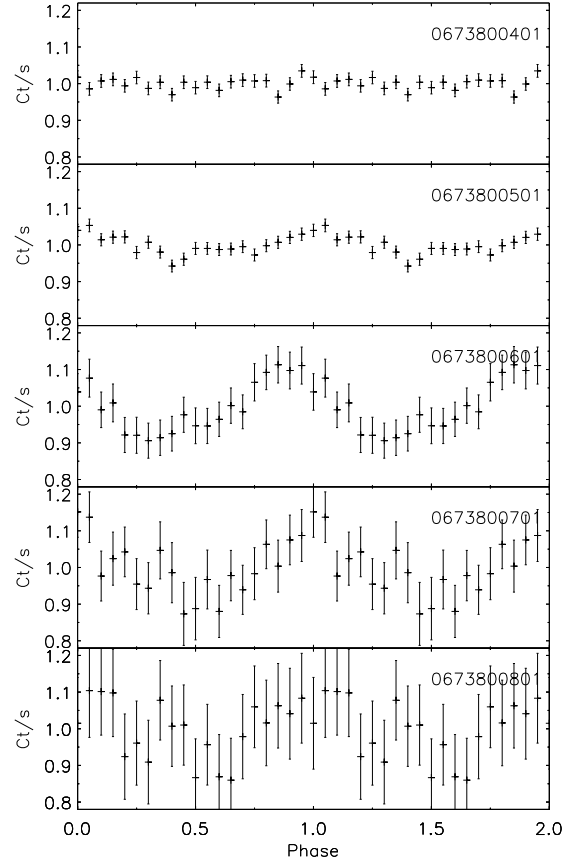


Figure 3. OM data folded on a period of 25.27 mins and $T_0=2455829.406$ (BJD). We have normalised the folded light curve by dividing by the mean flux, and we show the ObsID of the data in the top right hand corner of each panel (cf Figure 1). We do not detect a significant modulation at 25 min in either the top nor lower panels.

servation epoch. (We also did the same analysis for background subtracted light curves of various bin sizes). No evidence was found for any significant period above the 2σ level. On the 30 sec timescale, the rms of the light curves during X-ray quiescence was 0.02 cts/s while in the X-ray bright state it was 0.05 cts/s. Given the low count rate, we are not able to put meaningful constraints on the amplitude of putative periods.

4 X-RAY SPECTRA

Since KL Dra is detected with a low count rate in each individual observation (at best a few hundred counts in the EPIC pn detector) the resulting spectra for each epoch has a signal-to-noise too low to provide useful constraints on the emission or absorption model. We therefore combined data taken during the optical outburst state (by combining the first four epochs of data and also by combining the first five epochs of data) and also the optical quiescence state (the last three epochs of data). Further, we excluded time intervals which were contaminated by high particle background. Since the EPIC pn has a higher effective area and has a lower energy response compared to the EPIC MOS detectors (cf 2.3), we concentrated on data taken using the EPIC pn de-

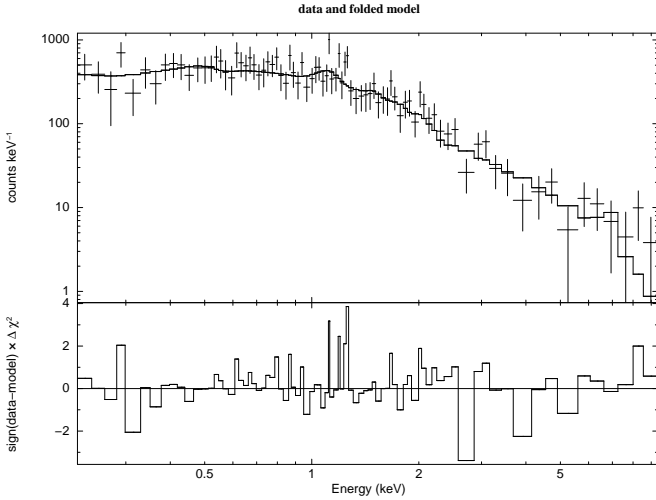


Figure 4. The X-ray spectrum of KL Dra observed during the faint optical state. The best-fit model using an absorbed single temperature thermal model with metallicity appropriate for CNO processed material is shown as a solid line.

tector. The resulting exposure for the X-ray bright spectra was 51.5 ksec (for the first five epochs of data) and the X-ray faint spectra 48.3 ksec.

We fitted the resulting X-ray spectra (Figure 4) using `XSPEC` and used the `tbabs` absorption model (Wilms, Allen & McCray 2000) plus a `mekal` thermal plasma emission model. (The absorption accounts for the interstellar absorption component). The resulting fits were good and the best-fit parameters together with the standard errors are shown in Table 3. There is weak evidence (less than 90 percent confidence) that the temperature during the optical outburst is lower compared to that during the optical faint state, while there is no evidence for a change in the total absorption column (Figure 5).

Our spectral fits were made assuming Solar abundance. However, we know that the abundance of material in AM CVn systems are non-solar. We then fitted the X-ray spectrum using the `vmekal` model assuming abundances appropriate for relatively low temperature CNO processed material and no hydrogen (eg $H=0$, $He=3.5$, $C=0.04$, $N=12.5$, $O=0.09$, Pols et al 1995, Ramsay et al 2005). The goodness of the fits were very similar and the resulting parameters consistent within the errors with the fits assuming Solar abundance (Table 3). Using the model for CNO processed material, we find that the unabsorbed bolometric flux during the optical outburst is 3.6×10^{-14} ergs s^{-1} cm^{-2} and 4.8×10^{-14} ergs s^{-1} cm^{-2} during the optical quiescence. This compares with a mean unabsorbed bolometric flux from all the *Swift* data of 10.4×10^{-14} ergs s^{-1} cm^{-2} (Ramsay et al 2010) which is biased towards the quiescent state. Given variations of at least a factor of 4 have been seen in the X-ray flux of dwarf novae in quiescence (Baskill, Wheatley & Osborne 2005), the factor of 2 difference in the unabsorbed bolometric X-ray flux between the *XMM-Newton* and *Swift* epochs is perhaps not surprising.

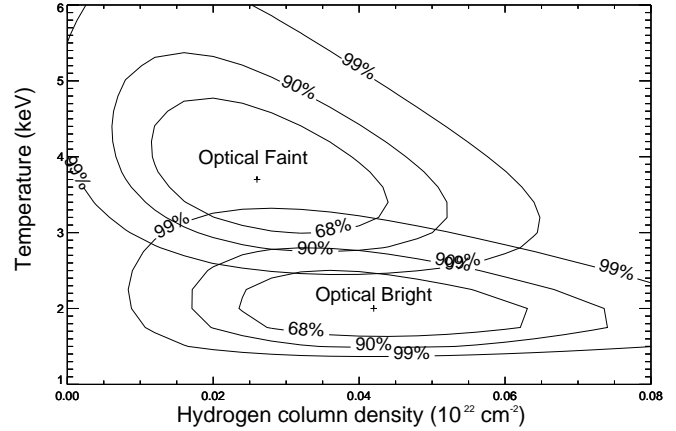


Figure 5. We show the confidence interval for the absorption versus temperature parameters for the spectra taken during the optical outburst and faint state and modelled using a thermal plasma model metallicity appropriate for CNO processed material.

5 DISCUSSION AND CONCLUSIONS

For dwarf novae in quiescence, material gets accumulated in the accretion disk as a result of Roche Lobe overflow from the late type main sequence star. Only a small fraction of the material in the disk gets accreted onto the white dwarf via a *boundary layer* between the accretion disk and the white dwarf. Although this layer is hot enough to generate X-rays and is optically thin to X-rays in quiescence, some fraction of X-rays detected in quiescence maybe due to a wind from the white dwarf (Perna et al 2003). Outbursts are thought to be due to a sudden increase in the mass transfer rate through the accretion disc due to a thermal instability originating in either the outer or inner parts of the accretion disc (Smak 1983). As a result, there is a sudden increase in the amount of material being accreted and the boundary layer becomes optically thick to X-rays. X-rays are therefore suppressed and replaced by emission at extreme UV wavebands (eg Wheatley, Mauche & Mattei 2003, Collins & Wheatley 2010). Eventually a cooling wave sweeps through the disc and the outburst ends (see Lasota 2001 for a review).

How do the AM CVn binaries differ from the ‘classical’ hydrogen dwarf novae? The most obvious contrast is their orbital period – KL Dra has an orbital period close to 25 mins while dwarf novae which show regular and super-outbursts, tend to have an orbital period shorter than 2hrs. The binary separation for KL Dra is approximately three times smaller than a CV with an orbital period of 2 hrs, implying a smaller accretion disc. The timescale for outburst cycles will therefore be shorter compared to dwarf novae. The other factor is chemical composition – AM CVn’s are devoid of hydrogen. Unlike dwarf novae, whose outbursts are largely driven by the ionisation of hydrogen, the outbursts of AM CVn’s are driven (at least partly) by the ionisation of helium (see Cannizzo (1984) and Kotko et al (2012)).

Since the shock temperature, T_s , is proportional to the mean molecular mass, μ , we may expect the T_s in AM CVn’s to be twice as hot as CVs ($\mu=0.615$ for Solar composition, and $\mu=4/3$ for an ionised helium flow). However, the temperature would be cooler if the velocity of the accretion flow

	$N_H \times 10^{20}$ cm ⁻²	kT (keV)	Flux _o ergs s ⁻¹ cm ⁻²	Flux _{u,bol} ergs s ⁻¹ cm ⁻²	Z	χ^2_ν (dof)
Optical Bright state	$2.6^{+2.2}_{-1.7}$	$2.6^{+0.6}_{-0.5}$	$2.7^{+0.4}_{-0.4} \times 10^{-14}$	$3.5^{+0.5}_{-0.4} \times 10^{-14}$	Solar	1.20 (57)
Optical Bright state	$4.2^{+2.4}_{-2.0}$	$2.0^{+0.6}_{-0.4}$	$2.5^{+0.3}_{-0.3} \times 10^{-14}$	$3.6^{+0.3}_{-0.3} \times 10^{-14}$	CNO	1.11 (57)
Optical Faint state	$1.8^{+1.7}_{-1.8}$	$4.1^{+1.1}_{-0.7}$	$4.4^{+0.5}_{-0.3} \times 10^{-14}$	$5.1^{+0.5}_{-0.5} \times 10^{-14}$	Solar	0.73 (81)
Optical Faint state	$2.6^{+2.0}_{-1.6}$	$3.7^{+1.2}_{-0.8}$	$4.4^{+0.4}_{-1.0} \times 10^{-14}$	$4.8^{+0.6}_{-1.2} \times 10^{-14}$	CNO	0.71 (81)

Table 3. The spectral fits to X-ray spectra derived from the optical faint and bright states. The CNO abundance is that appropriate for relatively low temperature CNO processed material (see text for details). The observed flux (Flux_o) is determined over the 0.1–10 keV band, and Flux_{u,bol} is the unabsorbed, bolometric flux.

did not reach the free-fall velocity as is thought to be the case in intermediate polars (eg Saito et al 2010). On the other hand, given that the shock temperature of intermediate polars has been observed to be several ten's of keV, this does not seem to play an important role. On the other hand this apparent discrepancy between the expectation of a high temperature plasma and the observed rather cooler plasma could be explained if a significant fraction of the X-rays did not originate from an accretion shock. One possibility could be that a fraction of the X-rays originate in a wind from the white dwarf or the accretion disc (Kusterer, Nagel & Werner 2009) which would have a temperature less than that expected for X-rays emitted in a shock.

KL Dra appears to be similar to most dwarf novae in that X-rays are suppressed during an optical outburst (U Gem appears to be the one exception, Mattei, Mauche & Wheatley 2000). There is weak evidence that in KL Dra the X-ray temperature is cooler during optical outburst compared to quiescence. In addition, while the softness ratio of the EPIC pn data shows some variation over the outburst, the X-ray spectrum is harder once the system is in quiescence compared to the first observations which were made in optical outburst. This is broadly similar to that seen in the dwarf novae SU UMa, whose X-ray spectrum during the optical outburst is significantly softer during the outburst (Collins & Wheatley 2010). In SS Cyg, the hardness changes in a complex manner, but during the outburst, the spectrum is (again) significantly softer (Wheatley et al 2003). With the detection of more examples of regular outbursting systems in wide field surveys (eg Levitan et al 2012) it maybe possible to expand the current sample of AM CVn systems which have X-ray coverage over the course of an outburst cycle.

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REFERENCES

- Barclay, T., Still, M., Jenkins, J. M., Howell, S. B., Roettenbacher, R. M., 2012, 2012, MNRAS, 422, 1219
Baskill, D. S., Wheatley, P. J., Osborne, J. P., 2005, MNRAS, 357, 626
Cannizzo, J. K., 1984, Nature, 311, 443
Collins, D. J., Wheatley, P. J., 2010, MNRAS, 402, 1816
Kotko, I., Lasota, J.-P., Dubus, G., Hameury, J.-M., 2012, A&A, in press, arXiv:1205.5999
Kusterer, D. J., Nagel, T., Werner, K., 2008, In ‘Hydrogen-Deficient Stars, ASP Conference Series, Vol. 391, 285, Ed Werner, K. & Rauch, T.,
Lasota, J.-P., 2001, NewAR, 45, 449
Levitan, D., et al., 2011, ApJ, 739, 68
Mattei, J. A., Mauche, C., Wheatley, P. J., 2000, JAVSO, 28, 160
Marsh, T. R., Horne, K., Rosen, S., 1991, ApJ, 366, 535
Mauche, C. W., 1996, ApJ, 463, L87
Perna, R., McDowell, J., Menou, K., Raymond, J., Medvedev, M. V., 2003, ApJ, 598, 545
Pols, O. R., Tout, C. A., Eggleton, P. A., Han, Z., 1995, MNRAS, 274, 964
Provencal, J. L., et al, 1995, ApJ, 445, 927
Ramsay, G., Hakala, P., Marsh, T., Nelemans, G., Steeghs, D., Cropper, M., 2005, A&A, 440, 675
Ramsay, G., et al., 2010, MNRAS, 407, 1819
Ramsay, G., Barclay, T., Steeghs, D., Wheatley, P. J., Hakala, P., Kotko, I., Rosen, S., 2012, MNRAS, 419, 2836
Saito, R. K., Baptista, R., Horne, K., Martell, P., 2010, ApJ, 139, 2543
Smak, J., 1983, AcA, 33, 333
Solheim, J. -E., 2010, PASP, 122, 1133
Steele, I. A., 2004, Proceedings of the SPIE, Vol. 5489, 679
Still, M., Howell, S. B., Wood, M. A., Cannizzo, J. K., Smale, A. P., 2010, ApJ, 717, L113
Tsugawa, M. & Osaki, Y., 1997, PASJ, 49, 75
Wheatley, P. J., Verbunt, F., Belloni, T., Watson, M. G., Naylor, T., Ishida, M., Duck, S. R., Pfeffermann, E., 1996, A&A, 307, 137
Wheatley, P. J., Mauche, C. W., Mattei, J. A., 2003, MNRAS, 345, 49
Willms, J., Allen, A., McCray, R., 2000, ApJ, 542, 914
Wood, M. A., Casey, M. J., Garnavich, P. M., Haag, B., 2002, MNRAS, 334, 87
Wood, M. A., Still, M. D., Howell, S. B., Cannizzo, J. K., Smale, A. P., 2011, ApJ, 741, 105